Shared Harvest: Aquaculture Innovations

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Shared Harvest Aquaculture Innovations
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For centuries, aquaculture, the farming of fish, aquatic plants and shellfish has provided mostly small scale yields for subsistence cultivation. Yet during the last few decades, aquatic farming has become one of the fastest growing food production systems worldwide. The staggering global transformation of aquaculture primarily occurred due to several key factors. First, massive increases in human populations require sustainable methods of providing nutrition. Second, international agencies such as the World Bank began promoting aquaculture in developing countries to furnish needed food provisions and also to encourage economic development. In addition, China initiated a series of economic reforms to advance the expansion of aquaculture. Third, wild harvests have been increasingly unable to keep pace with increasing demands (Environmental Health).

The expansion of aquaculture production raises a number of important questions in terms of best management practices and environmental costs. Significant approaches to best manage ecological impacts of aquaculture include prudent waste management strategies and resource conservation. Water, a necessary resource for aquaculture, is predicted to be the next valuable commodity that determines the prosperity of nations (Fortune; The Nation).

Sources of energy represent an expensive variable cost of aquaculture operations. Large and small-scale commercial fish farming ventures are challenged to reduce energy loads. Regional power grid managers ISO-New England (NE) have broadcasted "power warnings" and requests for NE businesses and homeowners to voluntarily cutback on power usage during peak summer and winter months. Power grid strains "stemming from overtaxed local distribution" fail under excessive demands and force "price hikes" which affect viability of fish farming operations (Boston Globe, 8/10/01). In addition, conservation and environmental concerns have exacerbated contentious debates over the benefits and costs of aquaculture. One of the imperatives of this fledgling NE industry is to create and implement sustainable, zero to extremely low impact aquaculture sites. New England regions are faced with escalating energy needs, yet may lead the way to new solutions through exploring cost effective, renewable energy sources for aquaculture.

Within the Commonwealth, The Massachusetts Department of Food and Agriculture supports, promotes and enhances long-term viability of Massachusetts agriculture with the aim of helping agricultural businesses become as economically and environmentally sound as possible. The Department's divisions and bureaus work to fulfill this mission through a variety of initiatives and programs.

In 1997, as a result of the efforts of the Massachusetts State Legislature, the Governor's Office, the Executive Office of Environmental Affairs and the Massachusetts Department of Food and Agriculture, the Massachusetts Aquaculture Grants Program (MAG) was created in response to the Commonwealth's interest in aquaculture development and the great need for diversification of fisheries and agricultural enterprises in Massachusetts. The MAG program encourages environmentally responsible aquaculture projects that can demonstrate public and industry benefit through work that will: result in the development and implementation of new technologies, products, processes or services; reduce aquaculture industry operating costs

thereby increasing business profitability; increase the productivity of Massachusetts aquatic cultivation endeavors; and aquaculture (http://www.state.ma.us/dfa/aquaculture)

During 2000, the MAG program was funded at the level $52,500. The program supported 3 projects that were proposed to address the criteria specified by the Aquaculture Grants Program. The Shared Harvest Aquaculture Innovations project in Lowell, Massachusetts was one of the three projects awarded funding under the Agraqua 2000 program.

The goal of the **Shared Harvest Aquaculture** Innovations were to (1) improve the cost-effectiveness and environmental sustainability of the prototype (water recirculating aquaculture) system, (2) to test the improvements, and (3) to develop detailed plans on scaling up to a commercially viable system. This project was a collaborative between University of Massachusetts Lowell Center for Family Work and Community, UML Center for Sustainable Energy, The Cambodian Mutual Assistance Association of Greater Lowell and the Lowell Heritage State Park.

The Shared Harvest: Aquaculture Innovations Partnership

The Shared Harvest: Aquaculture Innovations Partnership works with many low-income, recent immigrant communities who consume large quantities of fresh water fish. However, contamination of local waterways and consumption of locally caught fresh water fish represent a challenging regional health concern. Our overarching vision is to create affordable yet refined fresh water aquaculture systems through enhancing cost and energy effective fish farming technology. Transfer of technology to industry, recent immigrant communities, youth and the region needs to occur at a rate faster than typically achieved. Our first step towards this mission has been accomplished under MDFA funding. We share the process, outcomes, challenges and lessons learned begin with a description of the community and partners.

Lowell Canal

Why Lowell?

Lowell is geographically located at the confluence of two rivers, the Merrimack River and the Concord River. The power of the Merrimack's Pawtucket Falls was channeled into canals built in the 1790s by the Irish immigrants to drive the mammoth turbines of the textile industry. The first planned industrial city in the nation became a socially diverse city as waves of immigrants arrived from Ireland in the 1840s followed by Greek, French-Canadian and Polish to work in the textile mills. Lowell's textile mill era came to a close in the 1950s when the industry moved to southern states and eventually overseas.

The University of Massachusetts Lowell was born along the banks of the Merrimack River to provide science and engineer training needed by the textile industry. Established first as the Textile School in 1875, later uniting with the Lowell State College to form the University of Lowell in 1975. Today this university is a part of the five campus UMass system.

The mid-sized city of Lowell remains strikingly diverse. Historically, immigrants arrived during the nineteenth century reflect Irish, French-Canadian, Polish and Greek ancestry. Increasingly Lowell is shaped by immigrants arriving during the late twentieth century such as Cambodians and other Southeast Asians, Latinos, Africans, Brazilians and other Portuguese speakers from the Azores. Currently, every country of Africa is represented in Lowell's recent immigrant population. Lowell is now home to the second largest Cambodian community outside of Cambodia. Nearly forty percent of the current populace is minority, which is a 400 percent increase from 1970 when minorities constituted only 4 percent of the population. A national trend of shifting demographics is visibly evident in Lowell, Massachusetts.

The heart of the city is lined with a network of canals and immense brick textile factory buildings. Water comprises nearly a square mile of Lowell's surface area. Industrial degradation of Lowell's environment resulted in the Merrimack River categorized as one of the nation's top ten most polluted rivers. Today the city of Lowell and the university focus on sustainable production potentials and broadening environmental stewardship.

As an All American City 1999 designee, a Brownfields Showcase and HUD Enterprise Zone, Lowell is experiencing a rebirth or renaissance in terms of its social, economic, and educational approaches to development. Efforts to build on the richness of its diversity have been demonstrated through the creation of new national models for community preservation, community policing, and engaged universities. However, Lowell continues to face numerous challenges as well as a wealth of opportunities. In times of economic downturn, our city is looking at how to improve its economic base while improving its preservation of the environment. The question of how to effectively integrate the development of urban aquaculture has been posed by the work undertaken by the Shared Harvest initiative. Funding from the Massachusetts Department of Food and Agriculture has provided the opportunity to collaboratively link aquaculture efforts between disciplines at the university and with the community. In the next section, we outline the context of our university-community partnership, which is followed by a detailed description of the collaborative project undertaken. We

conclude with lessons learned though the process of facing development and partnership challenges.

Context of the Shared Harvest Partnership: The Partners

❖ ***Lowell's Cambodian Community***

Lowell experienced a 117% increase in its foreign born populations between 1980 and 1990. Much of this increase was due to the large numbers of Southeast Asians and Latino families arriving through a process of secondary settlement patterns due to the promise of economic opportunities and extended family reunification. Cambodians came to Lowell to rebuild their lives after escaping war torn Cambodia in the early 1980s. Despite their social and linguistic isolation, many families were able to locate work in factories. Factory positions required technical skill and manual labor capacity while limited English proficiency was sufficient to manage these types of available employment.

The Cambodian community represents courageous survivors of the Cambodian holocaust as well as Communist Khmer Rouge whose regime ruled Cambodia during 1975-1979. Cambodian refugees endured starvation, torture, persecution, rape and slave labor camps. Loss of family, homes, land, education and everything familiar leave a "hole in their hearts as well as in their pockets" (1996 Cambodian-American interview). Data from the 2000 Census illustrates some of the challenges faced by Cambodians in this community: Twenty-six percent (26%) of Cambodian families in Lowell are headed by a single female with an average family size of 5.03 persons. Only 46% of males and 22% of females over twenty-five have completed high school. The average per capita income for Cambodians is $5,120 and 42% live below the poverty rate. Due to cultural, linguistic and economic challenges many rely on a range of services provided by the CMAA.

❖ ***Cambodian Mutual Assistance Association: Courier Mill Building***

The Cambodian Mutual Assistance Association of Greater Lowell, Inc. (CMAA) was founded in 1984 as a non-profit agency dedicated to serving and improving the quality of life for Cambodian-Americans and other ethnic minorities residing in the greater Lowell region. Multi-service programs encompass educational, cultural, social, economic and community efforts targeted to meet the specific needs and challenges faced by the Southeast Asian cultures in the states. The CMAA envisions a unified, self-sufficient, economically strong, educated and empowered Cambodian-American community, which cherishes Southeast Asian cultural values while embracing American mainstream cultures. The CMAA serves as a resource center helping Southeast Asian communities successfully transit the bi-cultural American life style and experience.

Programs offered by the CMAA include:
Asian Refugee and Immigrant Economic Education Opportunity
BASICS Project: Building Access to Social, Interpreter and Community Services
Elderly Outreach & Assistance Program
Cambodian REACH 2010 Project
Citizenship Assistance Program
Computer Skills Training

Computer Recycling & Training Program
Employment Services Program - Mass Self Sufficiency Project
English for Employment Program
Komar Day Care Center
Lowell's Environmental J.O.B.S.: Justice on Brownfield Sites
Monoram Family Support Program
Parenting Skills Training Program
PEERS Project: Program to Enhance Elderly Refugees Services
Soldering Electronic Training
Urban Aquaculture Initiative
Young Parents Program
Youth Services Program

- ***The University of Massachusetts Lowell***

UMass Lowell envisions a robust U.S economy comprising a number of thriving, regional economies that are competitive globally. UMass Lowell's goal is to serve as a model of how a public university can marshal its capacities to help a region develop and maintain a thriving economy. Inspired and driven by this vision, the university is forging new linkages, strengthening existing ones, and creating strategies and technologies that are shaping the future of the region.

❖ ***Center for Sustainable Energy***

The Center for Sustainable Energy exists to develop systems to provide energy for various end uses in an environmentally and economically sustainable manner. Past and present projects in the center have focused on rural solar electrification, solar/electrolyzer/fuel-cell systems, electric buses, building thermal efficiency test methods, solar crop drying, solar design tools, solar resource databases, and now aquaculture. The center is unique in the degree to which it combines undergraduate and graduate education, research, public service, service-learning, and public education into its projects. Recent endeavors have included nine trips with students to remote areas of the Peruvian Andes to install solar photovoltaic and hydro systems designed by undergraduates and graduate students for transceiver radio communication, water purification, lighting, vaccine refrigeration, computers, and battery charging in medical clinics, schools, and town halls. Service-learning (which combines meeting real needs of the community with learning academic subject matter in courses) has been incorporated into more engineering courses than by any other faculty member in the country.

❖ ***The Center for Family, Work and Community***

UMass Lowell's Center for Family, Work, and Community builds partnerships between the university and community groups, nonprofit organizations, municipalities, corporate groups and consortia. The Center brings together staff, faculty, and students from across campus departments to partner with organizations to enhance their: strategic planning, teambuilding, program evaluation and research; community problem solving, conflict resolution, participatory grant writing, leadership development, educational programming, GIS, and community based research. Aquaculture programs have been based at the center for the last six years and have involved numerous partnership projects. The first aquaculture initiative included the Cambodian community under USDA, FSA, NEBHE, HUD and UML support.

The Center for Family, Work and Community

Shared Harvest Project Background

The University of Massachusetts Lowell and the Cambodian Mutual Assistance Association (CMAA) began a demonstration aquaculture project that was launched in the spring of 1998 in the basement of CMAA's building, located at 165 Jackson Street in Lowell. The goal of this project was to demonstrate the feasibility of raising Tilapia fish for sale to local restaurants and markets, and ultimately to consumers. This project worked to address several community needs. First, there are many Southeast Asian refugees who were farmers before fleeing their native land. Many are unlikely to develop job skills needed for industrial employment, or even for service jobs. They do, however, possess agricultural skills that are transferable to aquaculture. Second, fish are a staple of Southeast Asian cuisine. Fish is a source of much of the protein in the diet of the average Cambodian-American. Most of the fish sold in Asian markets is imported, either frozen or canned, from abroad. It is expensive, and it is not fresh. Third, due to over-fishing of the Atlantic fishing grounds, local fish catches have been drastically limited by the federal government, in order to preserve local species. Locally raised fish from fish farms would provide a lower cost supply of fish compatible with Southeast Asian cuisine to a market that includes low-income consumers who prefer fish to other sources of animal protein. The production of fish for this market would provide jobs requiring agricultural skills, which many otherwise hard-to-employ Southeast Asian refugees possess.

During the beginning of phase of Shared Harvest initiative, CMAA's English for Employment director received "train the trainer" instruction to enable him to teach basic aquaculture operations, such as water quality testing, feeding, measuring and weighing fish, and recognizing and treating common diseases in Tilapia. A seven-foot diameter tank was set up in the basement of the CMAA building in Lowell. As a result of daily feeding and care by the CMAA staff, assistance from the MFDA, USDA, NEBHE AQUA Educator's Network, UML faculty, students, and staff, and much donated labor, one hundred healthy Tilapia were ready for harvest, accompanied by a thriving population of hundreds more fingerlings and fry. Much was learned on how to raise Tilapia indoors. Our next step and goal of the project was to improve the cost-effectiveness and environmental sustainability of the prototype system, to test the improvements, and to develop detailed plans on scaling up to a commercially viable system. As a result of MDFA support we were able to constructively tackle the need for improvement in the aquaculture system to make it more cost-effective, environmentally sustainable, and rapid. Below, we outline the overall goals and tasks of the project funded by MDFA.

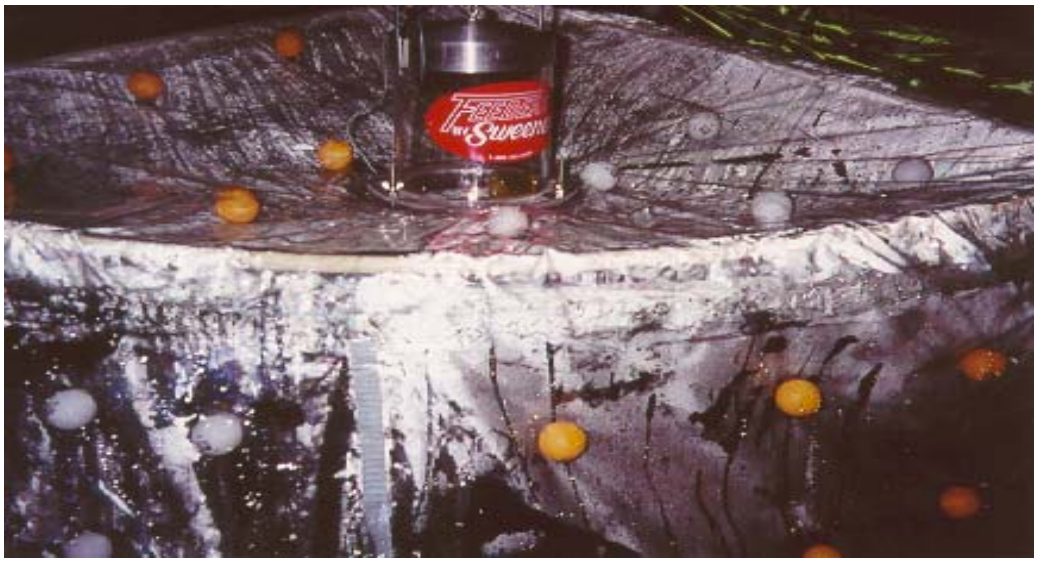
Description of Project Goals, Objectives and Work Completed under the MDFA Grant:
Results are described under the appropriate tasks in the statement of work in the contract with MDFA. Additional project data, information and photographs are located in report appendices.

(a) Conduct normal maintenance and operation of the UML recirculating culture system.

- The 745-gallon tank system was operated by the CMAA for over one year with roughly 100 healthy tilapia. In March 2001, the system was moved to KI 109 in the engineering building on the main campus of UML, in which it is still operating. The energy-saving features, hydroponics trays with water recirculation, and automatic feeder system were installed at that time. It operated for one year with no fish mortality (other than from the fish jumping out of the tank during the first few days after the moving of the tank, until we got the tank properly sealed up). During that time only make up water was added. In March 2002, several fish died after the pH dropped. We replaced over half the water in the tank with fresh water. Disease could have been a factor. We froze several of these fish in hopes that a fish biologist will examine them.

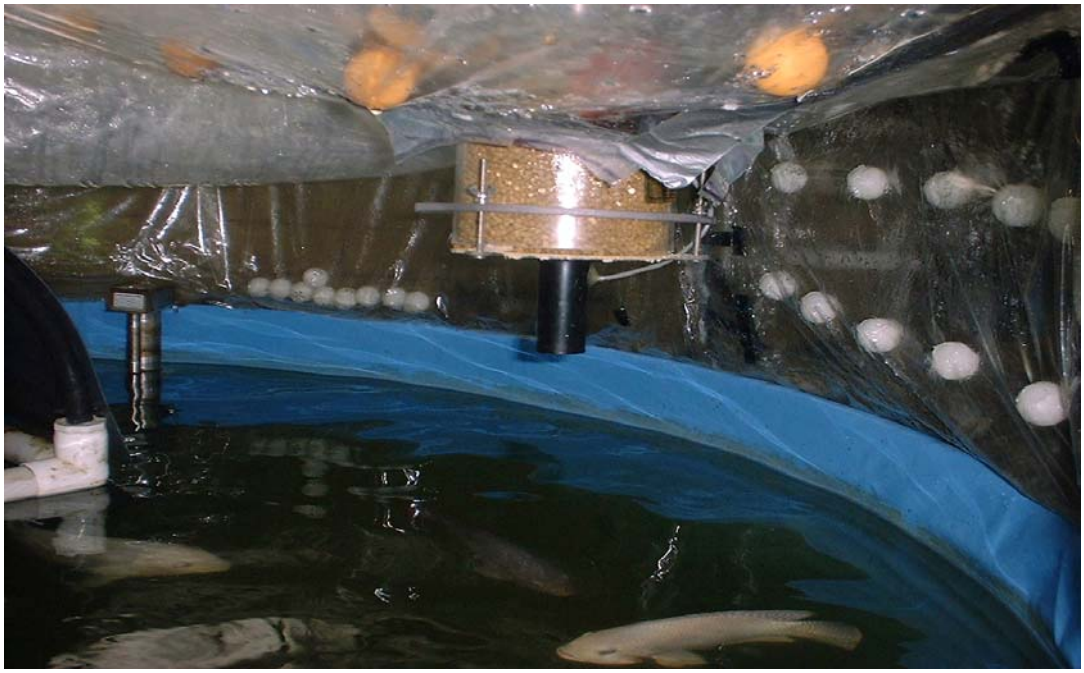
(b) Complete design modification to the existing recirculating culture system at the UML facility in effort to improve the energy efficiency of the system; including the purchase, construction and installation of a plastic covers to reduce evaporative loss.

- The plastic cover system has been operating successfully for two years. Energy analysis and measurements have shown that the heat loss coefficient of the tank has been reduced from 165 W/C to 57 W/C, a 2/3 reduction. Much of the energy savings is due to the reduction of evaporation. Water additions have gone from 10 gallons per day to an average of less than 3 gallons per day with no detectable adverse effects on the fish in the tank over a period of more than one year.



Tank Cover

(c) Design, construct and install an automatic feeding system that utilizes automatic timers. The automatic feeding system was installed a year ago. It feeds the fish twice a day. It requires cleaning every month or so, but it saves considerable labor. We very roughly estimate the labor savings from the automatic feeder, the plastic cover, the solid removal system, and the cages for small fish in the large tank to range from 70% to 90%, depending on the presence of babies to be raised.



Automatic Feeder

(d) Design and implement solid removal system modifications.

- The hydroponics trays were installed in March 2001, in part to allow for settling and collecting of solid waste. Once every three months, the solids are removed from the trays and allowed to dry for future use as garden fertilizer. Odors have not been a problem, unless the siphon is lost and the water does not circulate through the hydroponics trays.

Tank with Solid Waste Removal System

(e) Complete design, experimentation and analysis of a hydroponics system including the planting and harvesting of the hydroponics vegetables.

- The hydroponics trays have been much more useful for filtering solid waste than growing plants. Recently we have introduced clay pots (at the suggestion from the Rogers Middle School in Lowell), and the seeds germinated within a few days. The lettuce plants were growing better with the clay pots.

Hydroponics Trays

(f) Complete a quantitative and economic analysis of the relationship between fish yields and hydroponics crop yields from the modified recirculation culture system.

- The hydroponics yields have been negligible, unfortunately. The environmental and laborsaving benefits appear to far outweigh the yield of vegetables at this point. The system is essentially closed with no wastewater having been discharged for one whole year. We would recommend replacing at least some of the tank water more often than that, however.

Thriving Tilapia

(g) Complete feasibility analysis and updated business plan.

- The energy savings from the insulation and plastic cover will reduce operating costs for heating the water by 66%. Labor savings from the various systems we have introduced should be reduced by at least the same amount. The initial cost of these devices (cover, insulation, auto feeder, trays) is very small—on the order of $400. The payback would be less than a few months. These improvements are therefore very feasible. Solar systems for space and water heating would save even more.

Insulation for the Tank Sides

(h) Complete analysis of solar space heating and photoperiod for hydroponics crops.

- A detailed analysis of the energy benefits of a greenhouse for five tanks (similar to the 700 gallon tank in the lab) and solar hot water collectors on the roof was made by a graduate student in the solar engineering program, Numpol Sathonpattanakij. His report is included as a separate attachment. A significant portion of the energy for water and space heating could be provided by these systems. The life cycle savings depends greatly on the cost and type of conventional fuels that would be used for heating. For a new facility, these systems should be evaluated carefully for attractive cost and environmental benefits.

(i) Incorporate tasks identified by this scope of service into several engineering courses at the University of Massachusetts Lowell:

1. As part of a service-learning project in the solar fundamentals course (22.521), two students designed a solar hot water heating system for the aquaculture system.
2. This DFA project served as the focus of a capstone design course (22.424), in which the plastic cover and insulation system as well as the automatic feeding system and nets for fingerlings and fry were analyzed, designed, constructed, and tested by Sean Crowell and Arturs Rankis.
3. A directed studies course (22.534) had as its focus the design and construction of a solid waste filter bag system and the hydroponics system by Meredith Lewko.

4. An entire senior class in mechanical engineering analyzed the heat loss from the aquaculture tank and the dynamic response due to loss of heat and loss of air on the tank and the viability of the fish, as a miniproject in a course in dynamic systems (22.451).
5. The analysis of a greenhouse and solar hot water collectors for new aquaculture facilities in the Northeast was the focus of a solar engineering project (24.733) by Numpol Sathonpattanakij.

The above were introduced as service-learning projects into the courses. The idea of service-learning is to achieve academic subject matter goals while meeting the real needs of the community in a credit-bearing course. Studies have shown this pedagogy to be very effective in cognitive and affective measures.

Student designed Cage for Fry

(j) Create an aquaculture display at the Lowell Heritage State Park.

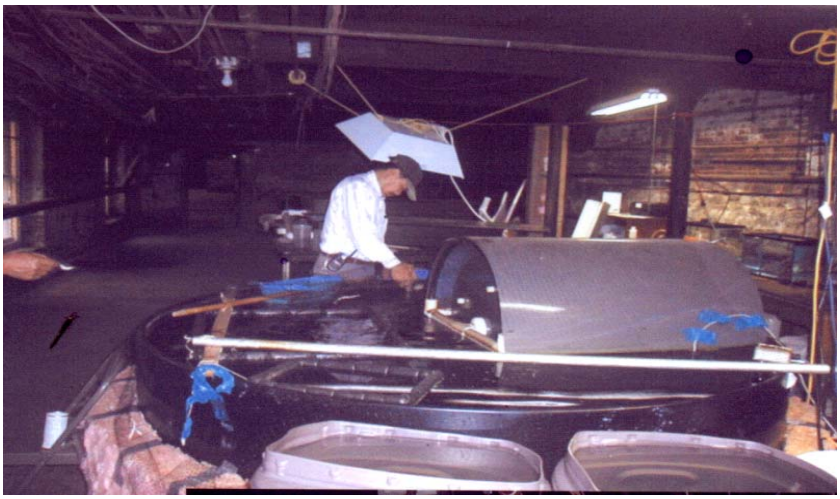
- A 250-gallon tank was set up to display tilapia aquaculture at the Bellegarde Boat House at the park for two years. Posters, signage and literature were included in ways that educated the general public on uses and benefits of urban aquaculture. The tank will be moved to one of the local schools to showcase and increase interest around issues of biodiversity and urban aquaculture.

Lowell Heritage State Park Bellgarde Boathouse

Scott Soares (nearest to the tank) at a Community Preservation Event in Downtown Lowell

(k) Involve Southeast Asian community in urban fresh water aquaculture principles.

- The Cambodian community staff members of the CMAA operated the fish farm recirculating system for almost two years. Danny Div, Operations Manager, involved several community staff members in the day-to-day operations. Community articles about the aquaculture initiative were published in the CMAA newsletters, brochures, and annual reports in both English and Khmer (examples included in appendices).



CMAA Aquaculture Site

(k) Link this work with UML finfish diet and nutrition research.

- Nutritional studies were limited due to the unexpected death of Dr. Randall Swartz as well as limited funding to sustain the finfish diet and nutritional research efforts. A tilapia lab was set up in a UML biology classroom for one year under UML funding. Nutritional researchers and the Shared Harvest partners collectively met with and toured industry sites to explore possible new links and partnership expansion.

(l) Disseminate results of this study.

- Recent professional presentations regarding the Shared Harvest Aquaculture Innovations include:

Silka, L, Chao, K. & West, C. (2002). *Partnerships Take Us Where We Don't Expect to Go … And We Are Better for It!* The Spirit of Community: The Healthy Communities New England Conference, Worcester, MA.

Duffy, J. & West, C. (2002). *Farming Collaborative Waters* (invited presentation). Committee for Federated Centers and Institutes Annual Dinner, U Mass Lowell.

Kleneiwski, N, Wooding, J., Forrant, R., & West, C. (2002) *Using the Assets of an Urban Setting for Community Development: Lowell, Massachusetts.* What's Right About Cities and an Urban Way of Life, Urban Affairs Association 32nd Annual Meeting, Boston, MA

Silka, L. & West, C. (2001). *Community Preservation: The Executive Office of Environmental Affairs/ University of Massachusetts Commonwealth Partnership*. Fifth Working Conference: Diversity, Culture and Sustainable Development, University of Massachusetts Lowell, Lowell, MA

Silka, L. & West, C. (2001). *Community Preservation and The Commonwealth Partnership.* 2001 Massachusetts Historic Preservation Conference: New Community Visions, University of Amherst, MA

Silka, L., Chao, K., & West, C. (2001). *Science That Matters: Building Research- Action Partnerships.* 109th Convention of the American Psychological Association, San Francisco, CA.

West, C., Silka, L., Duffy, J. (2000). *Immigrant Economic Development and Environmental Justice: Aquaculture as an Opportunity?* Royal Geographical Society: Towards Sustainability: Social and Environmental Justice, Boston, MA.

Other presentations in which the aquaculture project was mentioned in part:

Duffy, J.J., E. Tsang, and S. Lord, 2000, "Service-Learning in Engineering: What, Why, and How?" American Society of Engineering Education 2000 Conference, June.

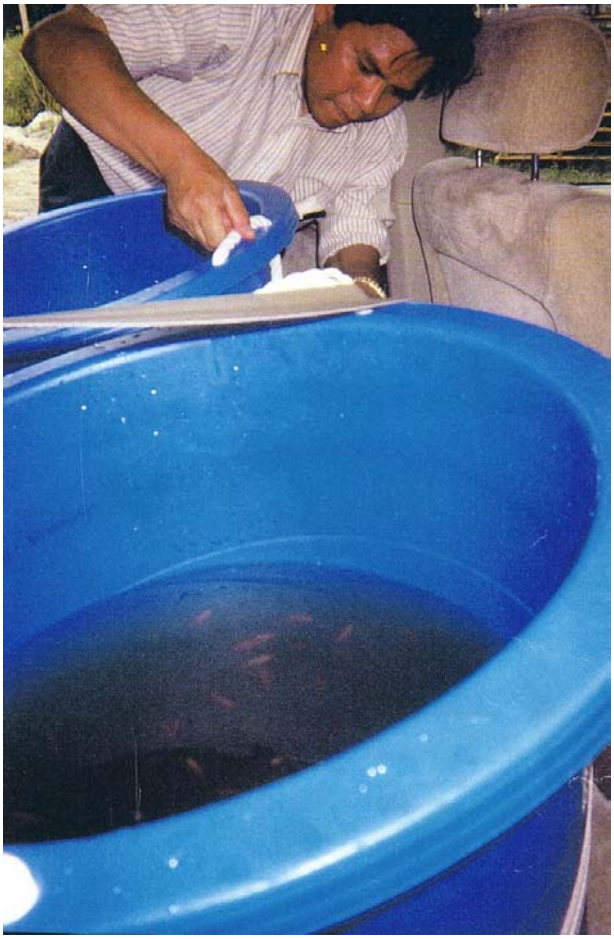
Duffy, J., 2000, "Service-Learning in U Mass Lowell courses," invited address, U Mass Lowell Faculty Conversations Dinner.

Duffy, D., and J.J. Duffy, 2002, "Introduction to Service-Learning: What, Why, and How," (invited four-hour workshop) Massachusetts Campus Compact Conference, April 4, U Mass Amherst.

Duffy, J.J., E. Tsang, and S. Lord, 2000, "Service-Learning in Engineering: What, Why, and How?" Proceedings of the American Society of Engineering Education 2000 Conference.

Duffy, J.J., 2000, "Service-Learning in a Variety of Engineering Courses," in Tsang, E., (ed.), *Design That Matters: Service-Learning in Engineering*, American Association of Higher Education, Washington, DC.

William Oakes, John Duffy, Thomas Jacobius, Panos Linos, Susan Lord, William W. Schultz, and Amy Smith, 2002, ” Service-Learning in Engineering,” Proceedings of the Frontiers in Education Conference, American Society of Engineering Education.



Challenges and Lessons Learned:

Moving from an aquaculture project concept to reality is a process. It is helpful if partners have worked together previously. Some factors that relate to successfully moving forward in the concept development of a new program include:

- History of meeting and working together
- Working relationships based on mutual understanding
- Commitment to the collaborative effort
- Collective planning and decision making processes in place
- Thoughtful evaluation and analysis of partnership
- Challenges as opportunities attitude

Despite considerable experience in working together as a university-community partnership (Southeast Asian Environmental Justice, HUD Community Outreach Partnership, CIRCLE, Environmental Risk Assessment, etc.), there was inherent complexity within processes of this university-community partnership. The University of Massachusetts Lowell's mission emphasizes the role of the university in providing intellectual resource for regional economic and social development. Even though Lowell does not experience traditional town –gown issues, challenges experienced in the Shared Harvest Aquaculture Innovations included:

- Communication Processes
- Ownership and Responsibility
- Capacity for Project Commitment
- Adequate Funding

Communication Processes

Ongoing, open communication between partners is key to project success and sustainability. However, successful communication that is inter-organizational and cross-cultural represents complex processes that require both cultural sensitivity and continuous effort to create mutual understanding. One of the underlying questions of the Shared Harvest Aquaculture Innovations inquired about how a university-community partnership may work together to create community driven solutions to effectively address the challenges of developing sustainable urban aquaculture? In our effort to create a sustainable university-community partnership that facilitates this process, we encountered a mix of communication, ownership, capacity and funding issues that ultimately concluded this university-community aquaculture partnership. As a process of learning through unexpected and expected challenges, we follow with a brief outline of specific challenges and lessons learned.

Cross Cultural Communication. Often misperceptions and inaccurate assumptions short circuit cross cultural communication. During the process of this work, it was implicitly understood that there were important differences in styles of communication. Nonetheless, creating mutual understanding that bridged cultural differences continued to be a process requiring candid mutual learning. One of the lessons gained through this partnership was a greater understanding of cultural differences based on class and socio-economic status.

Socio-economic status and community image is important to many Cambodians. Agricultural backgrounds are not considered important to relevant to an urban life here in America. Many

Cambodians have greater interest in gaining experience and education in technical fields. Often there are not many opportunities to choose a life other than agricultural within Cambodia. However, in the states, there are many new resources and choices to be made that differ from a traditional life in Cambodia. Not only is life different here in the states, the natural environment differs in climatic conditions. It is easy and natural for most Cambodians in Cambodia to create a fishpond by their home. However, in the states, the challenges of understanding unfamiliar resources as well as negotiating greater regulatory procedures are daunting for most. Natural aquaculture conditions experienced within Cambodia versus potentially high technology aquaculture in the states represents a paradoxical dilemma. Transferring knowledge and use of aquaculture technology presents a worthwhile educational challenge. It seems possible to promote use of aquaculture technology as a way to gain important socio-economic status and image within the Cambodian-American community. One of the difficulties of generating sustainable aquaculture interest is a devalued agricultural image.

In addition to status and image issues, the majority of Cambodian's have experienced profound traumas and losses, especially in terms of family. Maintaining filial relations often take on a greater value in the aftermath of the Cambodian genocides. In the case of our aquaculture project, weekend and evening time away from a family to care for fish was seen as an unhealthy choice for project staff. Danny Div, the CMAA Shared Harvest Project Manager, also divided his time between two other roles at the CMAA in addition to the fish farm operations and caring for his growing family.

Planning and Decision Making. As a component of inter-organizational communication, shared planning and equitable decision-making represent key communication processes. It is important to establish joint planning, problem solving and decision making processes that occur on a regular basis face to face. However, the tyranny of structure and different styles of leadership can often disrupt effective communication between divergent organizations. One of the specific issues that emerged in this aquaculture partnership turned on the matter of harvesting tilapia. The harvesting concern was expressed in several messages that conveyed harvesting location, division of labor, and distribution of harvested fish.

CMAA recently opened a Buddhist Meditation Center on the third floor of the mill space. Monks from the Cambodian Buddhist temple taught meditation techniques and offered a schedule of group meditation hours. Harvesting of fish within the same building in the basement was deemed a violent act that was in direct conflict with peace generating meditation activities. Next, the division of labor was suggested by Danny Div as a best management practice to separate everyday care of the fish and caretaker attachment from the ultimate act of harvesting. Various modes, styles and schedules of distributing the tilapia product had been discussed. However, a multitude of delays involving mentioned concerns and a serious power outage resulted in a discouraging loss of the harvestable tilapia. The coordination of data recording and sharing was also problematic.

Ownership and Responsibility

- *Clarification of Roles*

Community and University are often unclear about what role the university should be in terms of collaboration such as the Shared Harvest Aquaculture Innovations. Clearly, UML's mission emphasizes the role of the university in providing intellectual resources for regional economic and social development. However, the university is not structured to provide service delivery or run community coalitions. The university provides its best roles by providing background information, doing research, convening groups, involving students with skills, carrying out training, bringing interdisciplinary perspectives and providing neutral territory for community. Ongoing communication is needed to clarify and re-clarify roles and responsibilities of partners over the course of a project. Negotiating project ownership links to roles and the evolution of project accomplishments. Creating opportunities for shared ownership represents an ideal that can be challenging to achieve.

- Shared Ownership

Each partnership will no doubt experience questions of ownership and responsibility. One of the specific ownership questions encountered during the project being discussed focused on rights and timing of access to the CMAA aquaculture facilities. UML student and faculty hours spent onsite tended to vary from a typical nine am to five pm schedule of the CMAA organization. Failed after-hours site access limited and weakened university involvement and support. Attempts to assist with equipment set up, gather data for reports and project evaluation were stunted and ineffective. However, the Cambodian community organization had suffered numerous thefts from their recently acquired computer labs, which was met with intensified security technology and measures. Creating separate aquaculture site access without compromising CMAA security could have resolved this specific shared ownership predicament.

Capacity for Project Commitment

- *Short Term versus Long Term Commitment.*

There is a natural mismatch of goals, priorities, and timelines that exists between community needs and university agendas. For example, universities typically focus on long-term efforts whereas community organizations are often driven by short term, tangible outcomes. Driven by different agendas, it can be difficult to anticipate the mismatches that evolve. Yet it remains important to anticipate and prepare for unique collaborative challenges. Often, the coordination of efforts can also be underestimated and limited by organizational capacities of both partners. Difficulties of partnering become exacerbated when either or both partners are over committed and over extended.

A few examples of university challenges included transitory student involvement and support. A key graduate student dropped out of the ME program for financial reasons. Loss of planned student activities changed our timeline and created role confusion in terms of project responsibilities between university and community partners. Should the community partner perform the student tasks that would also advance the community operation? Yet a community partner with little reserve resources and overworked staff are hard pressed to fill in for the university. Without an immediate student replacement of interest and involvement, portions of the project did not take place as planned.

Adequate Funding

Long-term commitment requires adequate funding levels for sustaining partnership involvement. Our collaborative fish-farming venture began and continued to operate with minimal funding. Aquaculture operations need to achieve an economy of scale in order to be self supporting and competitive in the market. Sufficient levels of funding can also ignite and engage community interest with hope and vision. The role of community human service organizations such as the CMAA is to provide a range of essential social services in the most effective and least expensive manner for its community members. Community-based organizations in general, cannot bank roll full time employment and benefits for aquaculture staff. On the other hand, the community often operates under the false assumption that the university has deep pockets of easily accessed funding. Community struggles to gain access to resources are often similar to the university challenges of maintaining streams of funding to sustain projects. The community can also view the university as competing for the same limited resources.

Successes and Next Steps:
Challenges and lessons learned contributed to the successes and next steps of the Shared Harvest Aquaculture Innovations project. Work undertaken during the MDFA funding built and expanded the aquaculture infrastructure within Lowell. Important next steps and other impacts resulting from this MDFA funded work are described next.

Project Splash: Aquaculture, Science, and Culture

Project Splash is entering its second year as a new after school program that explores links between culture, science, food sources and the environment. This enrichment program draws on community-based interest in fish and water in ways that engage middle school youth from largely refugee and immigrant backgrounds. Over 100 middle school students participate in hands-on activities that demonstrate how sciences work together to create environmentally safe urban aquaculture. The new program represents a partnership between the University of Massachusetts Lowell, the Rogers Middle School, Lowell Housing Authority, the New England Board of Higher Education's AQUA Network, GEARUP, and the River Ambassadors. The program is funded in part by the National Science Foundation, the Lowell Public Schools, and GEAR UP.

E.N Rogers Middle School

UMass Lowell Biology Lab.

Peru Aquaculture

In the near future, two aquaculture systems are planned to be designed and installed by students and local residents of two remote villages in Peru. The Malvas tank will have trout and the San Miguel tank will have crayfish. Both species are at present indigenous to the respective areas. River pollution has driven off or reduced the numbers of fish locally. The fish are expected to enhance the nutrition of the subsistence farmers in the villages and to provide some extra income for export.

The planned aquaculture site in Malvas, Peru

Regional Education Aquaculture Partnership

REAP is a new partnership program that was developed by: The Center for Family, Work, and Community at the University of Massachusetts Lowell; The New Hampshire Aquaculture Association (NHAA), and the Cooperative Extension University of New Hampshire. The Goals of REAP are Education, Information, Aquaculture Promotion and Training. REAP program objectives include: To provide hands-on, on farm site training workshops and tours of aquaculture facilities; To provide knowledge & identification of regional fish species; To utilize cultural events as a foundation for the education, training and information transfer necessary, to insure safe aquatic food handling and consumptive practices; To establish familiarity with Aquaculture and farm-Raised fish; and To develop foreign language informational lay language booklets on aquaculture, it benefits its opportunities and its uses. Targeted Groups for REAP workshops include – Asian, African, Central European Immigrants, Low-income Urban Residents, Middle and High School Students. The program is funded in part through the Rhode Island Farm Viability Grant.

Danny Div and Melvin Murrel

New market links and community links have emerged due to the work of the MDFA funded Shared Harvest Aquaculture Innovations. A local market has requested the delivery of 80 pounds of farm-raised tilapia a week. Efforts to realize this market potential are currently being explored. Affordability and marketability of locally farmed fish needs to be further investigated within recent immigrant and refugee communities in the Northeast. Most of the Southeast Asian neighborhood markets offer inexpensive frozen fish imported from Asia. In addition, many Southeast Asian families supplement their diets with fresh water catches. However, there is concern over the health of the fishing sites used for such consumption.

Concluding Reflections

As a university that emphasizes community-university partnerships, we hope that lessons learned are helpful to others interested in creating similar partnership efforts. We have included a number of project documents in the appendices. Contact information is also included for additional information requests. In sum, we share the following suggestions for reflection:

Timing of the partnership work is important
Strengthen relationships, partnership and communication processes at regular intervals
Create market links at the beginning of an aquaculture venture
Include reality checks for joint problem solving
Community support and data are important to assess and evaluate progress
Build teamwork and leadership
Assess local market and consumption of fresh fish
Establish educational opportunities, technical training and support
Assessment of access to water and water quality
Be aware of environmental impacts from aquaculture on regional waterways
Carry out science that is useful for communities
Build train the trainer models within the community
Link project work to academic goals
Evaluate effective methods to coordinate efforts and share resources

Project Personnel

Professor John Duffy and Research Associate Cheryl West were co-principal investigators of the project. Ms. West was responsible for the administration and coordination of the project. She has coordinated the project since it's beginning. Dr. Duffy was responsible for the technical designs and analysis and oversight of student involvement. Several UML ME and Solar Engineering students were engaged during the course of the project work. Meredith Lewko initially began some of the engineering work as part of a directed studies course. She had planned to use the project work, particularly the waste treatment studies, as the focus of her ME master's thesis. Sean Crowell and Arturis Rankis devoted their entire senior capstone design course to this project. Solar engineering graduate students Vinay Anaanthachar, Ardarsh Das, and Numpol Sathonpattanakij contributed to project. Danny Div of the CMAA continued his daily care and feeding of the fish and donated countless hours to the project during the first year. He has built up considerable aquaculture expertise and teaches English as a Second Language at the CMAA, and can teach other Cambodians in Khmer about the system. The Lowell Heritage State Park featured a 350 gallon aquaculture tank in the Bellegarde Boathouse for over two years as a demonstration site. Gunther Wellenstien, Environmental Science student assisted with the finfish diet and nutrition research investigating potential protein alternatives and nutraceutical enrichments, and was available to assist with the some of the Shared Harvest needs. Leading water quality analyst, investigator and UML environmental instructor, Charles Panagiotakos, continues to provide guidance and support for this initiative as well new aquaculture related efforts. Dr. Joe Buttner at Salem State College conducted "hands on " training for Danny Div during the first year of the partnership. Scott Soares, MDFA State Aquaculture Coordinator, provided invaluable guidance, encouragement, and ongoing key information.

KHMER LOWELL

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CMAA Quarterly Magazine

Happy Khmer New Year of the Dragon! 2000

Highlights in this issue:

This is definitely Graduation Season!...

Post Khmer New Year Festival 2000 at the Tsongas Arena...

Violence Reflective of our Society...

CMAA Programs & Services...

Light of Cambodian Children Activities...

Youth Peer Leaders Receive Community Award in Boston...

S.E.A. Water Festival...

And other News...

Students of the Employment Services Program graduate from their job trainings, see p. 13

Right:
This is a picture taken from the graduation ceremony from the Comprehensive Outreach Education Program (COEC) on April 13, 2000. Of this group, the following are from the CMAA's Board of Directors and Staff: Mr. Seang Sak, Ms. Lillian Pelletier, Ms. Chenda Seth, Mr. Sovann Khiam, and Mr. Samuth Koun.

Comprehensive Outreach Education Program

Students from Lowell H.S. come to CMAA to Job Shadow

CMAA's Aquaculture Project